19. Studies indicate that angular accelerations in any plane of less than $2°/sec^2$ may not be perceived by pilots without supplementary visual cues.

20. The angular acceleration in the vertical plane, generated by a runaway or sticking secondary trim switch condition, would be of less than $2°/sec^2$ for several seconds. Unprogrammed primary trim changes in the same plane could go undetected for 1 to 2 seconds, particularly if the initial motion was masked by light to moderate turbulence.

21. The time interval between the initiation of an unwanted trim motion and the initiation of corrective action was critical in determining whether the corrective action would be effective.

(b) Probable Cause

The Board determines that the probable cause of this accident was an unwanted change in longitudinal trim which resulted in a nosedown high-speed flight condition that was beyond the physical capability of the pilots to overcome. The initiating element in the accident sequence could not be specifically determined. However, the design of the aircraft flight control system was conducive to malfunctions which, if undetected by the crew, could lead to a loss of control.

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3. RECOMMENDATIONS AND CORRECTIVE ACTION

The testimony at the public hearing indicated that the FAA policy regarding the Delegated Option certification procedure was to accept certification data from the manufacturer and to review the data in the areas the FAA felt were necessary. The FAA also indicated that they participated in flight tests only when a new regulation was being applied to an aircraft, or when the manufacturer produced a new design feature that had not previously been certificated by them. The trimmable stabilizer in the B-99 was such a new design feature, but the FAA did not participate in the flight testing of this item.

This type of stabilizer has been in use for a long period of time on various commercial and military aircraft, and the problems that were associated with it should have been well known throughout the industry. These problems have included excess stabilizer-up angle, runaway trim potential, and flight conditions where the elevator power might not be capable of overcoming the stabilizer power. Since this type of stabilizer has been in use, various devices have been incorporated in the systems to provide more information to the crew and to

eliminate some of the known hazards that could evolve from its use. These devices have included audible warning of trim motion, stabilizer position indicators, restrictions to stabilizer-up angles, and published emergency procedures developed to deal with the results of various malfunctions in the system.

The Board notes that the modifications applied to the trim system of the B-99, since the accidents, are similar to those which have been previously applied to large aircraft.

The fault analysis used by the manufacturer and the FAA to certificate the longitudinal trim system of the B-99 was reviewed and the Board concludes it was inadequate. As stated in this report, a fault analysis that did not consider the total operating environment was not complete. Therefore, the Board recommends that:

The FAA review the existing fault analysis system and give consideration to requiring the completion of safety analyses in a manner similar to that required by Military Standard 882, System Safety Program for Systems and Associated Subsystems and Equipment: Requirements For.

These types of analyses should be applied to all aircraft offered for certification that can be used for the carriage of passengers for hire.

The Board recommends that the FAA take action to:

(1) require direct participation of FAA personnel in the certification of all newly designed aircraft components;

(2) review its aircraft certification system for possible procedural changes which would ensure that lessons learned in investigation of large aircraft accidents and incidents would be applied, when appropriate, to certification of small aircraft;

(3) bring recommendation (2) above, to the attention of those units within the FAA that are charged with the certification of small aircraft.

CORRECTIVE ACTION

On August 1, 1969, the Board recommended to the Administrator, Federal Aviation Administration, that he take certain interim actions immediately. (See Appendix F.)

On August 6, 1969, the FAA replied that they were in the process of implementing recommendations resulting from a special evaluation of the B-99 conducted July 9 and 10, 1969. This implemented recommendation included some of the actions recommended by the Board. The Administrator believed that the actions being taken by the FAA would correct the trim system deficiencies. (See Appendices D and F.)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

August 26, 1970.